Temperatur stabilisering ved brug af faseskiftende materiale - PCM

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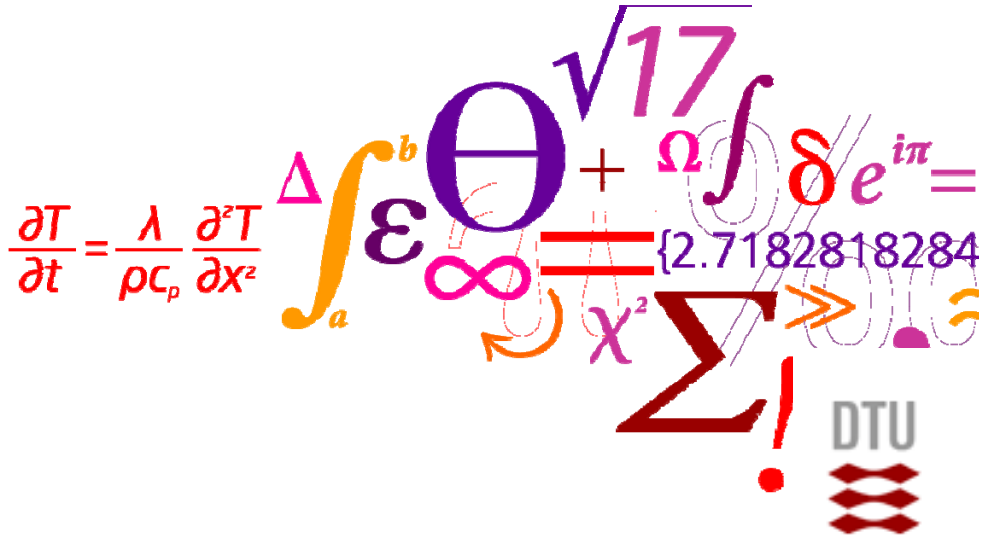
Carsten Rode & Amalie Gunner



DTU Civil Engineering
Department of Civil Engineering

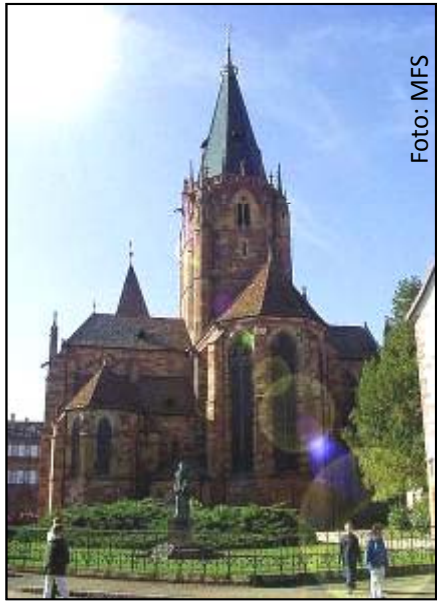
Phase Change Materials – latent varme lagring for at opnå større komfort i fx et kontor

DTU Civil Engineering
Department of Civil Engineering

Hvad er formålet med PCM?

Modern lightweight architecture

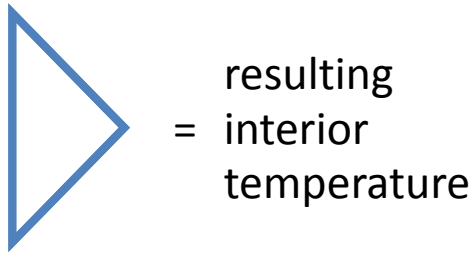
Heavy old building



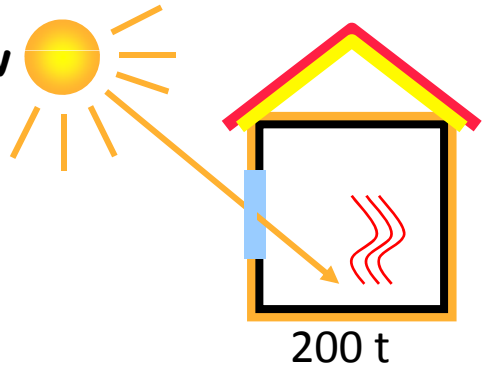
PCM is the ONLY technology, which is able to STOP temperature increase at indoor application, without causing energy expenses

PCM in summer – Insulation in winter

- **In winter thermal insulation reduces heat loss through the walls**
- **In summer most energy entry is through the window**
- **Effective temperature control via:**
  - **Heat storage**
  - **Shade**
  - **Night ventilation**
  - **Insulation**



= resulting interior temperature



Heat storage: two types

Latent varmelagring

Phase transition

"Melting/Crystallization heat"

Ice-Water: $\Delta H = 333$ kJ/kg

at 0C

333 kJ/kg

Sensibel varmelagring

Temperature difference

"Heat capacity"

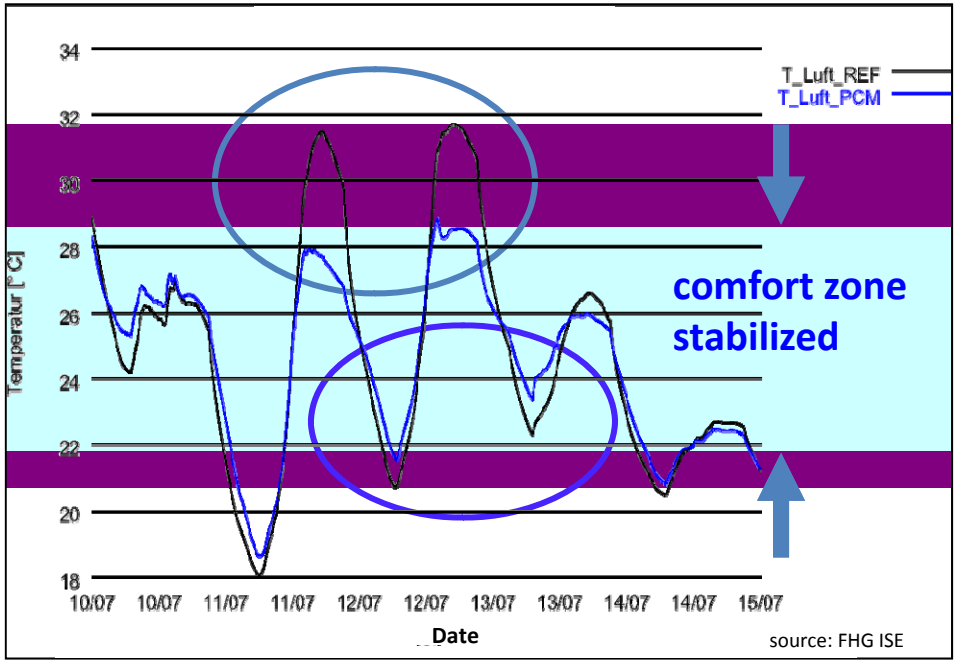
Water: $c_p \approx 4.2$ kJ/kg · K

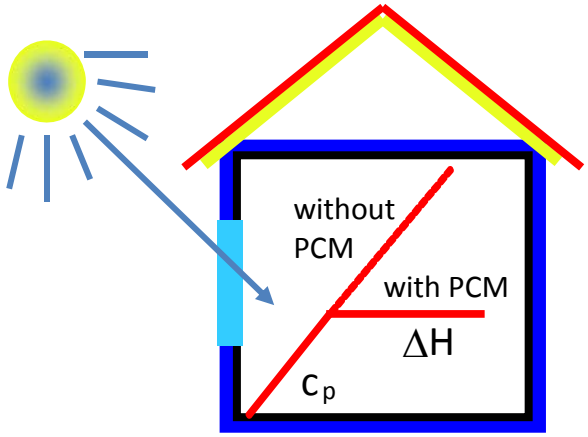
1C → 80C

332 kJ/kg

Use of PCM in construction

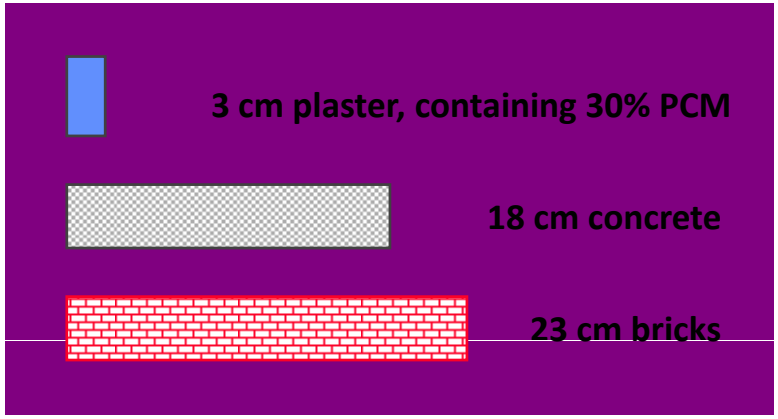
Comparison Air Temperatures [°C]





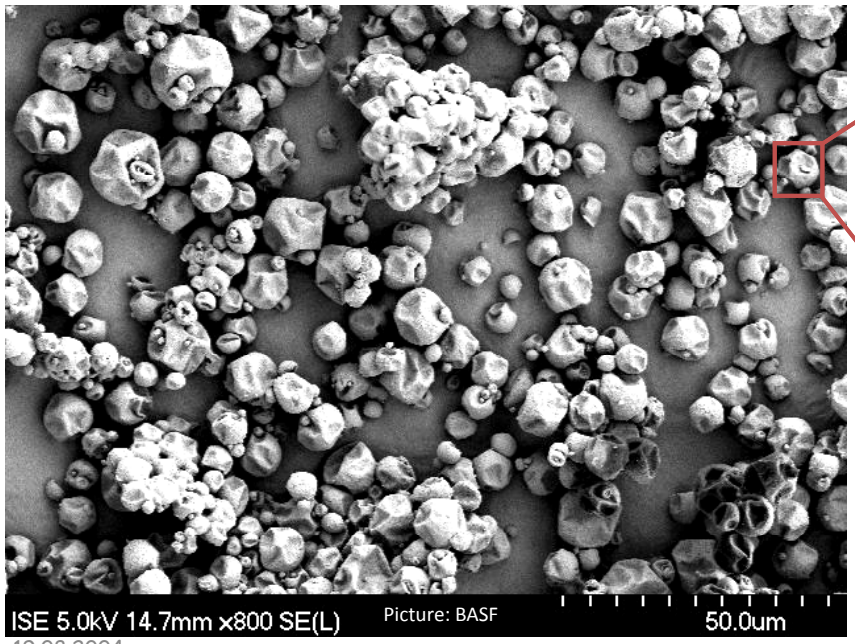
PCM traps heat from room

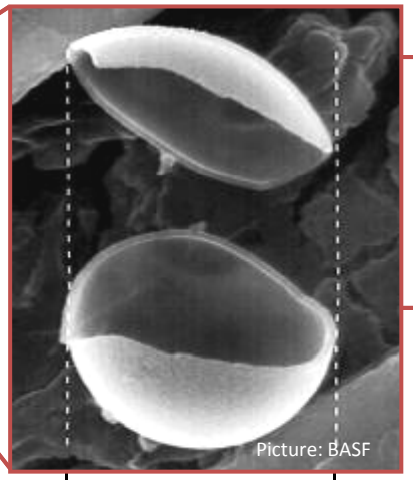
Recrystallisation to recharge PCM



Microcapsules as packaging

- Building materials soaked with PCM can result in exudation.
- Microcapsuled latent heat stores overcome this problem.





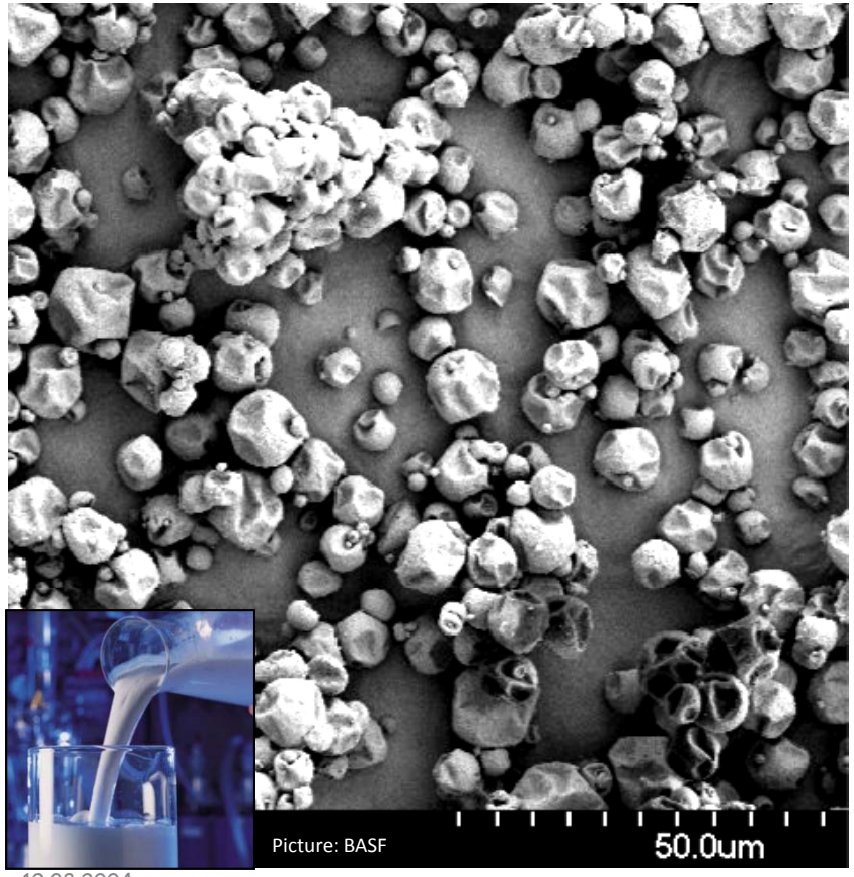
Polymer coating

Wax
Fp: ca. 26C
Δ H: 110 J/g

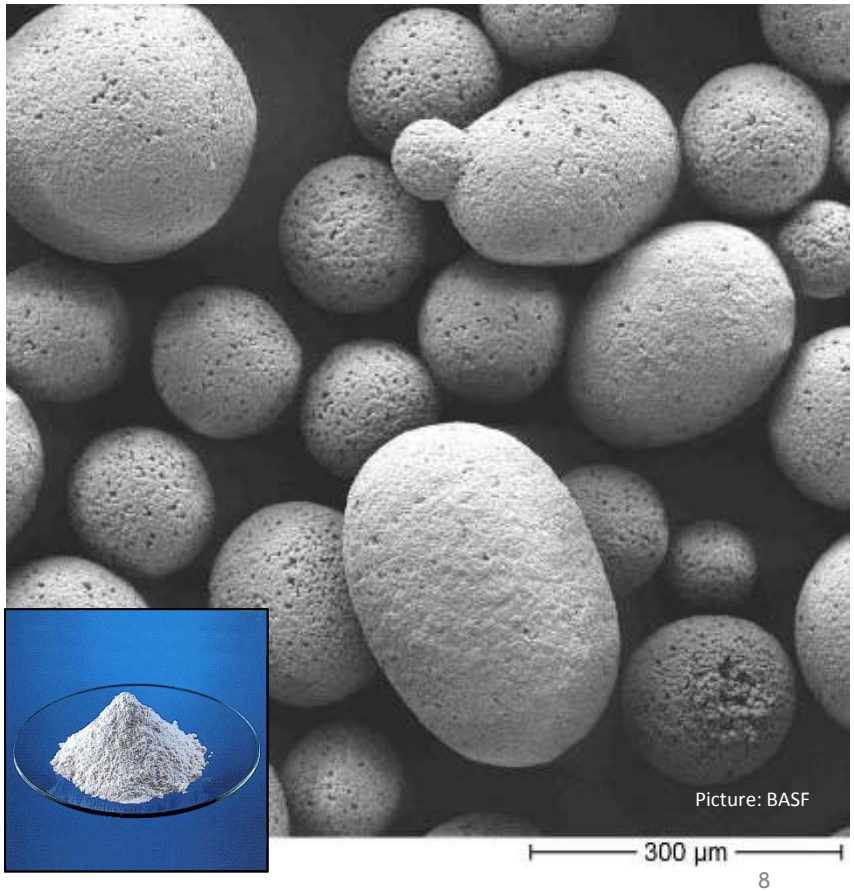
5 µm

Material background - Micronal® PCM

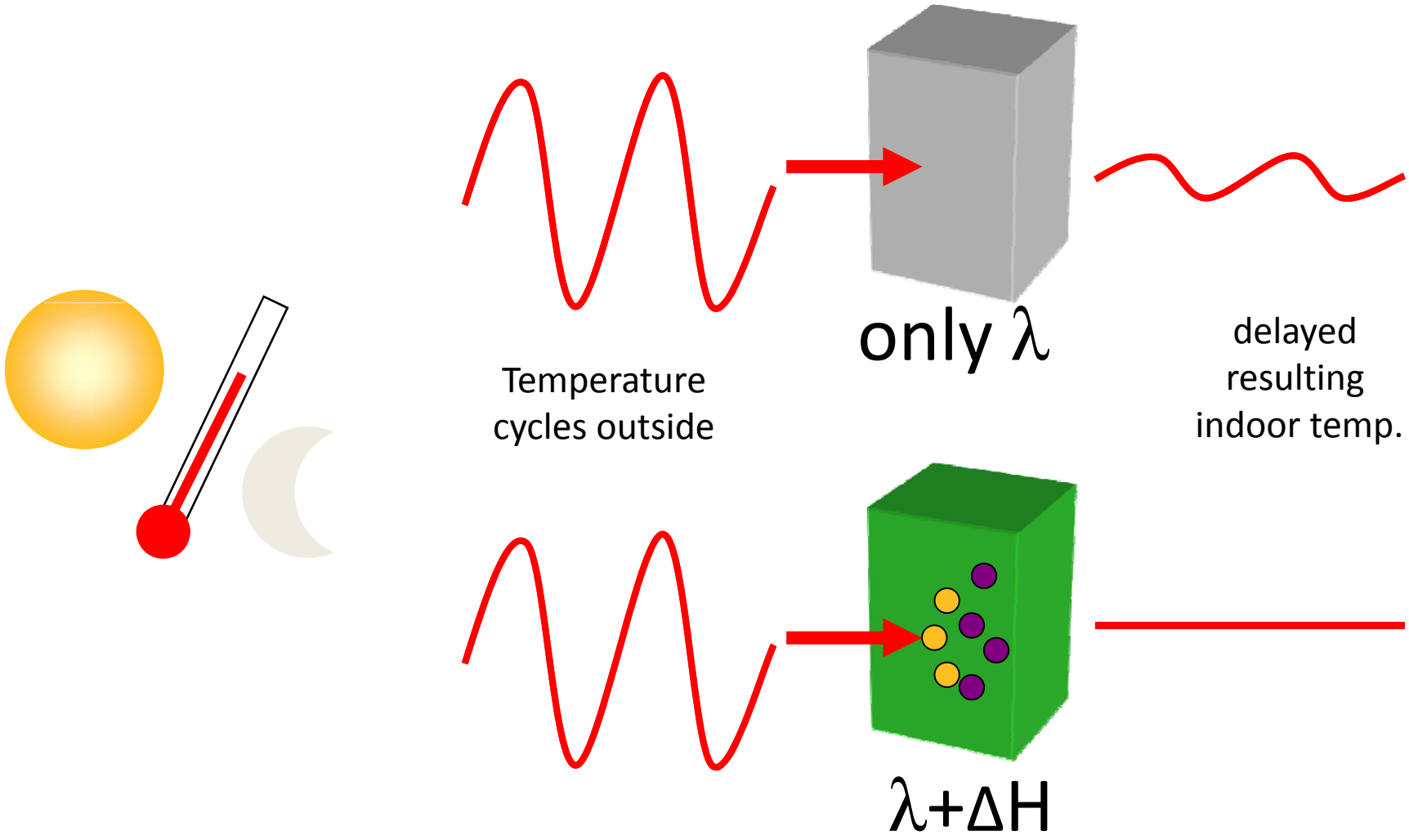
Liquid



Powder



PCM - Aircrete
Insulation AND Thermal Capacity



Ready-to-use
Micronal® PCM SmartBoard™ 23/26

Length	**2,00 m**
Width	**1,25 m**
Thickness	**15 mm**
Weight	**11,5 kg/m²**
PCM content	**approx. 3 kg dry/m²**
Heat capacity (latent)	**min. 330 kJ/m²**

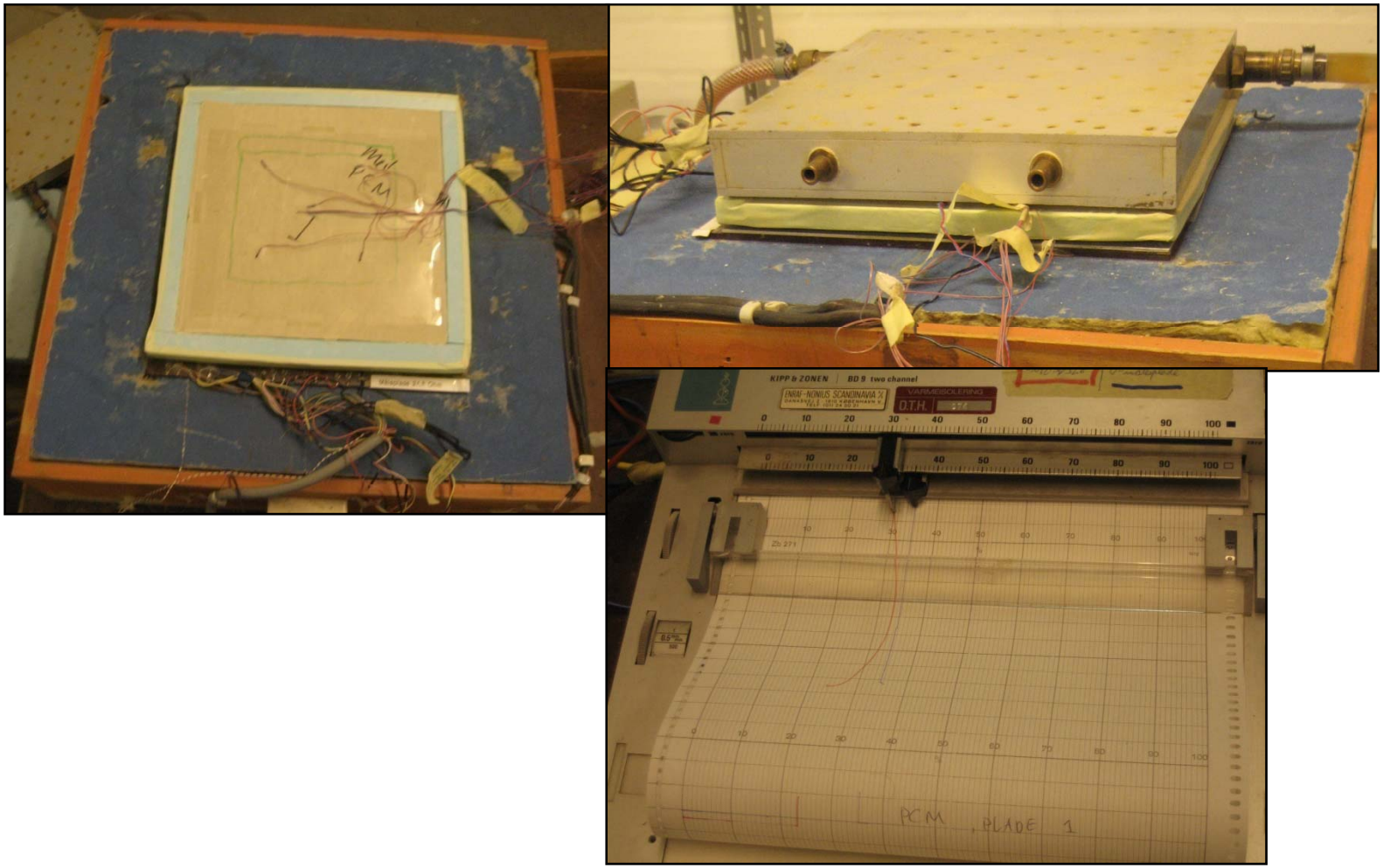
Picture: BASF


Picture: Haus der Gegenwart, Munich, Germany

Forsøg på DTU

- Varmeledningsevne
- Varmekapacitet
- Temperaturvariation
- Temperaturvariation i rum

Varmeledningsevne



PCM er temperaturafhængig

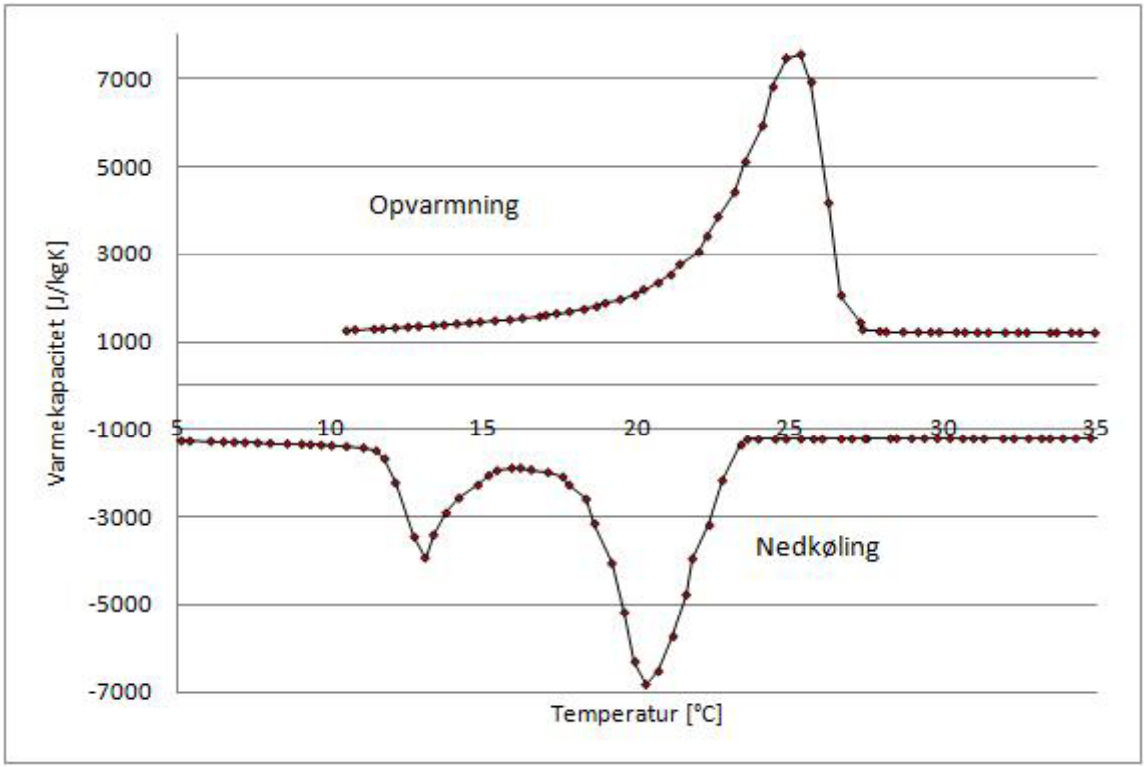
- Bestemmes for temperatur under- og over smeltepunktet.
- T_{15} & T_{30}

- T_{15} < smeltepunkt.
  - $\lambda = 0{,}14$ W/(m^2 K)
- T_{30} > smeltepunkt.
  - $\lambda = 0{,}15$ W/(m^2 K)

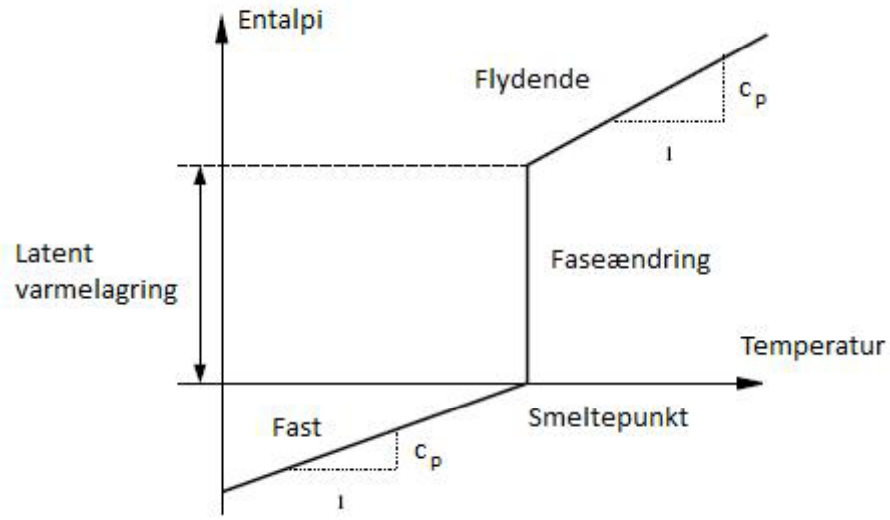
Varmekapacitet og entalpi

Varmekapacitet for gips med PCM

Varmekapacitet for gips med PCM



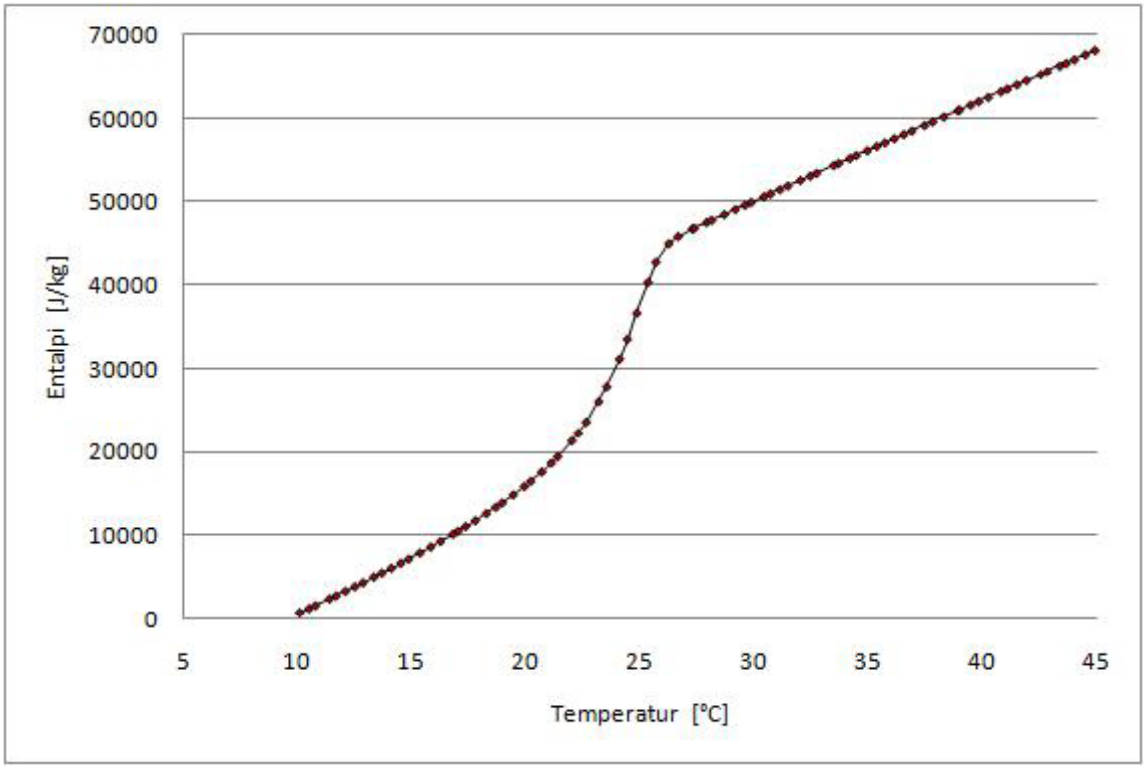
Tilstandsfunktionen



Bestemmelse af den specifikke entalpi

$$h = h_0 + c_p\,(T-T_0)$$

Entalpi for gips med PCM



Sammenligning

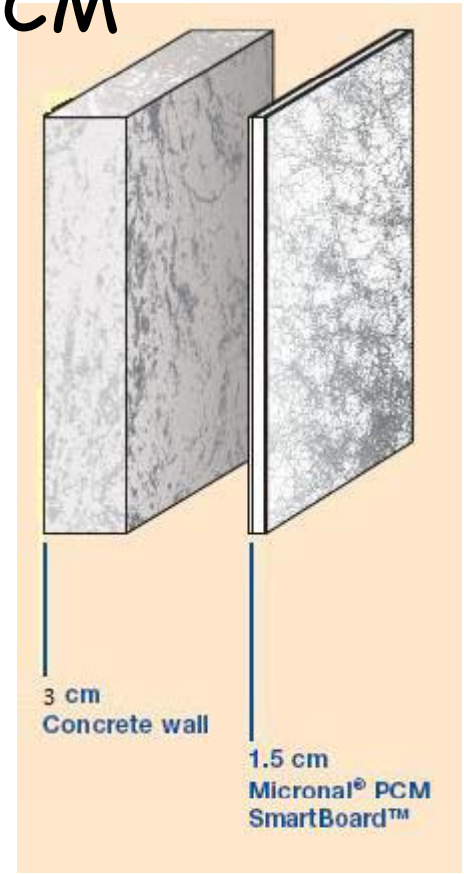
For 1m^2 gips på 15 mm med 30% PCM

- ΔH = 290 kJ/m^2

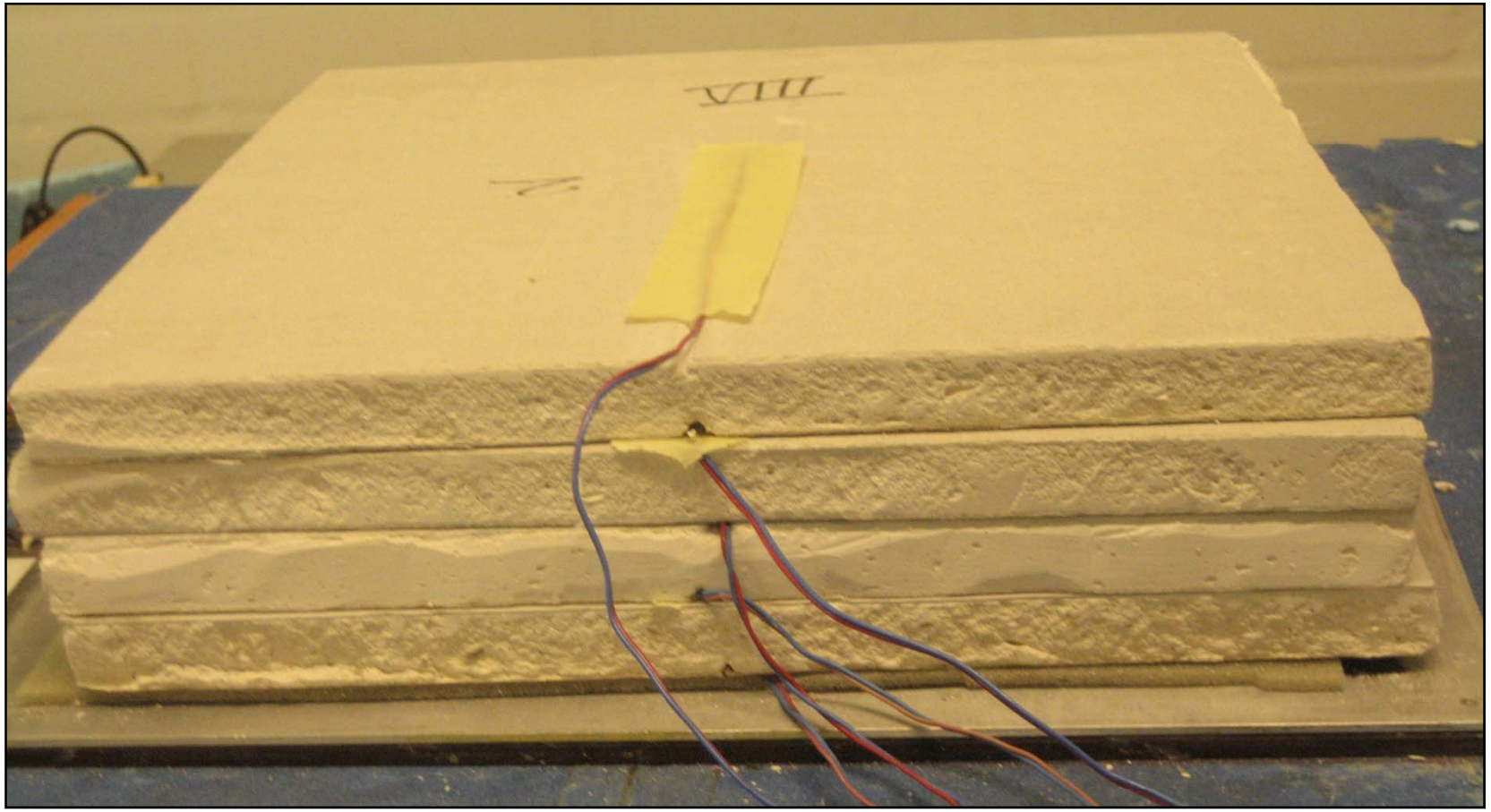
For 1m^2 beton på 15mm

- ΔH = 165 kJ/m^2

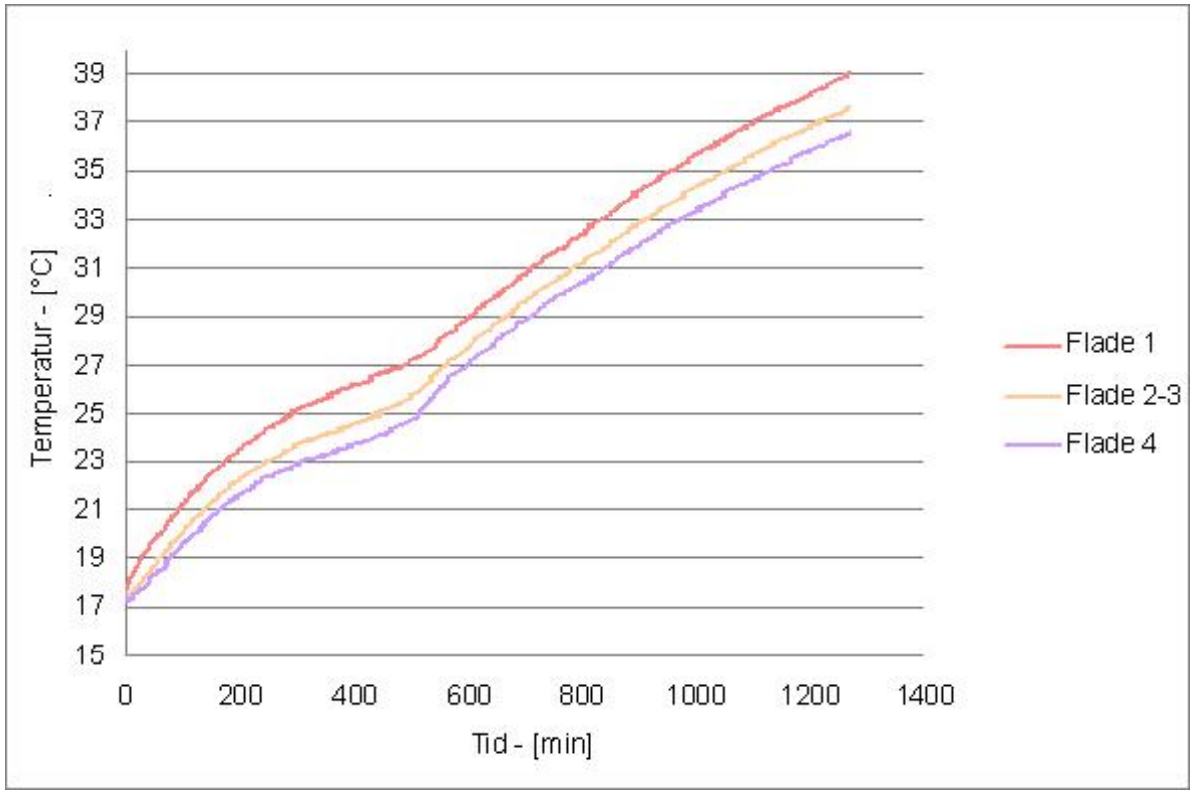
med et temperaturinterval på 5 grader



Temperaturvariation



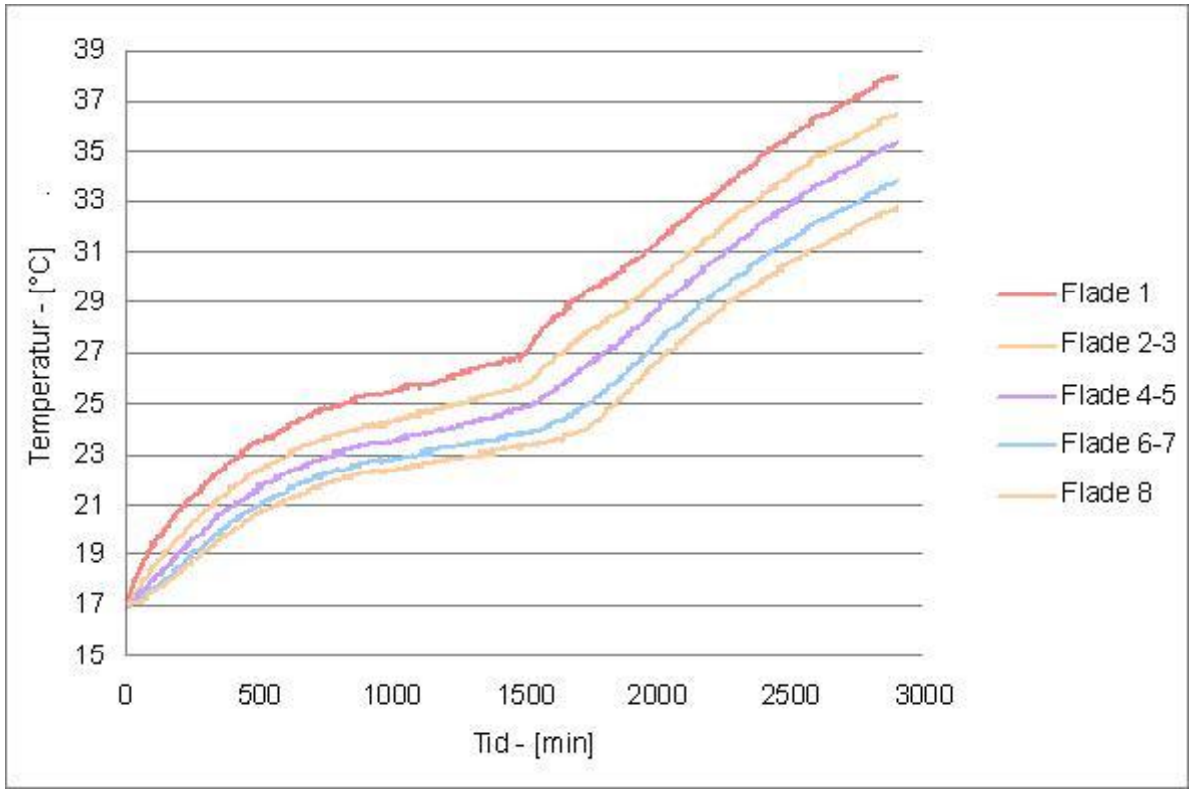
Gips/Smartboard



Der opsættes en gipsplade på 'indersiden' af hensyn til brandfare

Lille dæmpning ved 24 - 27 ºC.

Gips/3 Smartboards



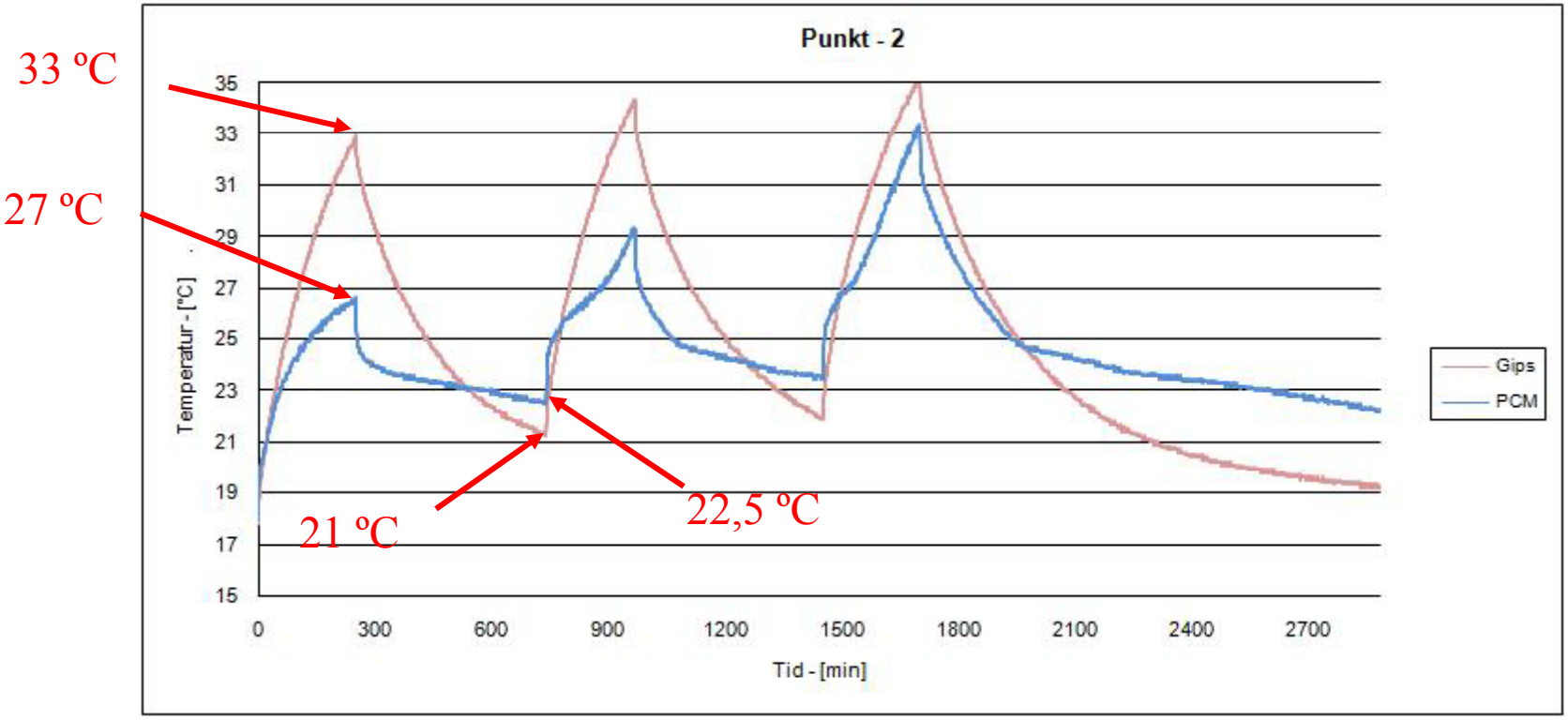
Stor dæmpning grundet meget PCM.

Konklusion

- Faseændringen sker i et interval, 22-26 °C.
- Temperaturgradient dæmpes ved faseændring → Latent varmeoptagelse.
- Dæmpning sker først ved ca. 25 °C pga. brandbeskyttende lag.

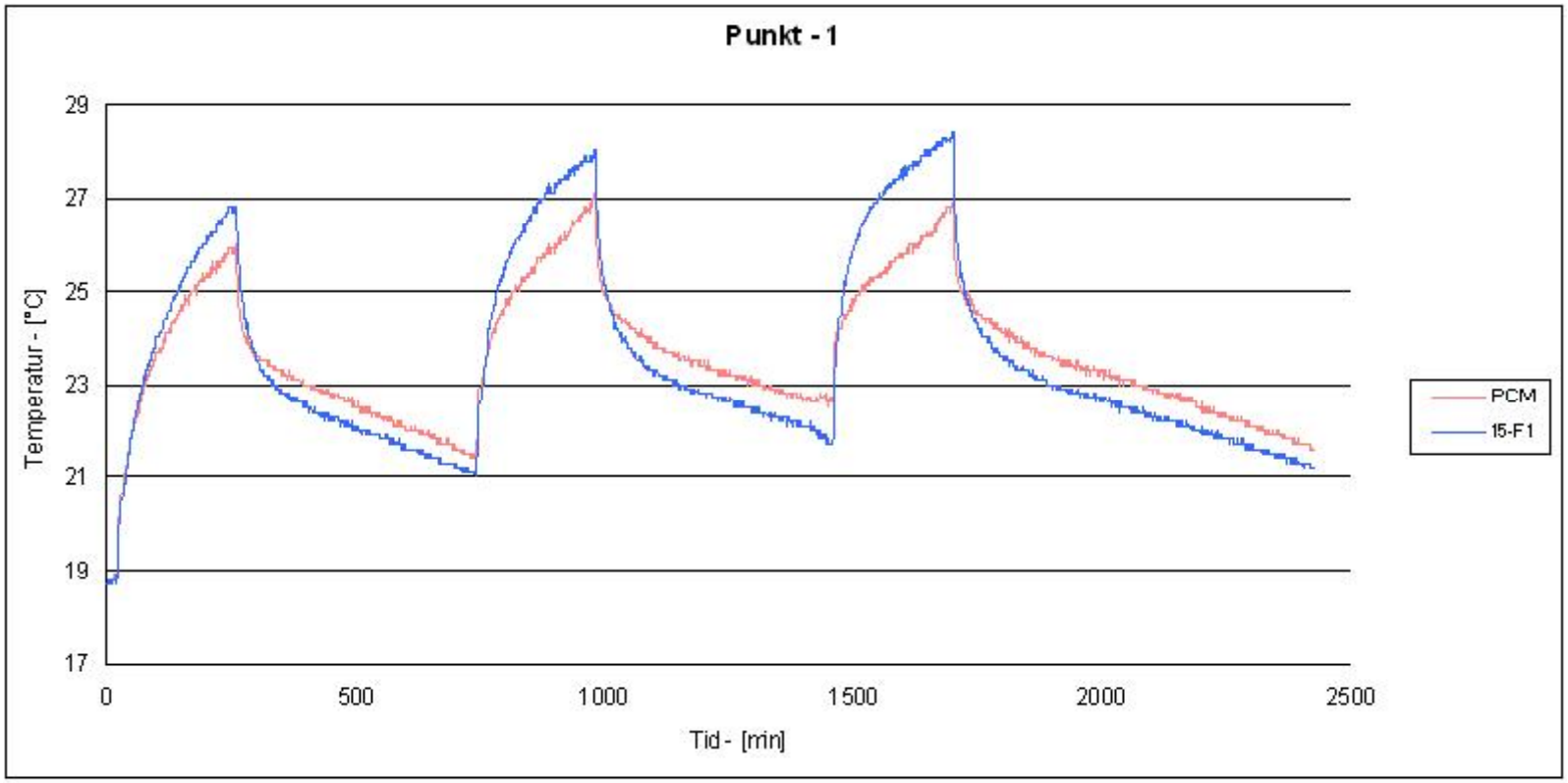
Temperaturvariation i rum

Indvendig væg



Brandbeskyttende lag

- Opsat et lag brandbeskyttende gips, 15-F1.



Næsten ingen forskel mellem de to rum.

Konklusion på forsøg

- Mindre temperaturvariation ved rummet opbygget af smartboards.
- Virkning reduceres væsentligt, hvis ikke temperaturen kommer under smeltepunkt.
- Brandbeskyttende lag nedsætter PCM'ets effekt.
- Smartboards reducerer:
    - Maksimal temperatur
    - Temperaturvariation
- Temperaturen skal under smeltepunktet.

Bygningssimuleringer med PCM

- Der er tilføjet mulighed for at lave beregninger med faseskiftende materialer i BSim

- Faseskiftende materialer kan anvendes som varmekapacitetsforøgende tilslagsmateriale i f.eks. gipsplader, porebeton, puds og beton. Anvendes materialet i f.eks. en gipsplade kan denne opnå samme termiske egenskaber som en ½-stens mur.

- Faseskiftende materialer er derfor oplagt at anvende i kontorbyggeri for at undgå/reducere kølebehovet. Muligheden for at regne med faseskiftende materialer findes indtil videre som en beta-version i den seneste opdatering af BSim. Brug af den nye funktionalitet kræver at der benyttes den nyeste database (BSim2008.mdb).